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Terminal 4 Remedy

Data Replacement Evaluation for Terminal 4

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1 Introduction

As outlined in the *Pre-Remedial Design Investigation Work Plan* (PDI Work Plan; Anchor QEA 2019), the focus of the pre-remedial design investigation (PDI) for the Port of Portland (Port) Terminal 4 (T4) Action Area, also known as Sediment Decision Unit (SDU) RM 4.5E (T4 SDU), was the collection of additional sediment data to fill data gaps associated with sediment management area (SMA) delineation, consistent with the *Record of Decision: Portland Harbor Superfund Site* (ROD; USEPA 2017a).

Abundant historical surface sediment data exist for the T4 SDU (Figure F-1). However, these existing data are 10 to 20 years old, and due to the prevailing sedimentation rates at T4, these surface sediment samples are no longer representative of current conditions. The PDI sampling of surface sediment was conducted to address these data gaps and characterize current surface sediment concentrations throughout the T4 SDU. The following were considered in the development of the PDI sampling at T4: 1) historical data; 2) post-dredge samples at Berth 401 from a 2015 maintenance dredging event (two surface samples); 3) post-dredge samples at Berth 410 from a 2017 maintenance dredging event (three surface samples); and 4) 2018 Pre-Remedial Design (RD) Group samples both within and outside of the existing T4 ROD SMAs. The 2018 Pre-RD Group data will be used to supplement the T4 PDI data, as described in the PDI Work Plan. Therefore, the 2015 post-dredge data (two surface grabs), 2017 post-dredge data (three grab samples), and the 2018 Pre-RD Group data (24 surface grabs) have been combined with the 2019 PDI surface sediment data (62 surface grabs) to create the current surface sediment dataset with locations shown in Figure F-2.

Multiple lines of evidence have been considered to develop the site-specific evaluation to support replacement of the historical surface sediment data (1997 to 2008) with the current surface sediment data (2015 to 2019). As listed in the U.S. Environmental Protection Agency's (USEPA's) documentation of the March 19 and 20 Remedy Design Workshop, "Attachment 1 – Remedial Design Principles, Data Replacement" (USEPA 2019), these multiple lines of evidence include the following:

- Unbiased sampling approach
- Sampling density
- Age of the data
- Deposition versus erosion/scour potential
- Evidence of natural recovery
- Heterogeneity of substrate
- Presence of outliers

Each of these considerations are discussed in this document.

1.1 Sampling Density and Unbiased Sampling Approach

The PDI sampling was conducted to evaluate historical data for the T4 SDU and fill data gaps for delineating SMAs, refine the conceptual site model, and apply the Technology Application Decision Tree to the refined SMAs. Surface (and subsurface) data were collected to better define the horizontal and vertical extent of contamination for T4 focused contaminants of concern (COCs)—polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs)—and to better characterize current surface sediment conditions where historical data are outdated. A third ancillary focused COC—dichlorodiphenyltrichloroethane (DDT), together with its degradation products and their isomers (collectively DDx)—was also considered in this evaluation.

The PDI surface sediment program consisted of 62 surface grab samples, including 53 grabs in open-water areas and 9 diver grabs in underpier areas, collected on a statistically unbiased grid of approximately 150-foot centers throughout each of the T4 subareas (i.e., Berth 414, Slip 3, Wheeler Bay, Slip 1, and Berth 401). Combined with the 5 post-dredge locations collected in 2015 and 2017 and the 24 locations collected by the Pre-RD Group in 2018, these 91 sample locations are collectively within 100 feet (Figure F-3) of the historical surface sediment sample locations encompassed by the T4 ROD SMA.

The USEPA-approved PDI sampling approach was based on the recommendation in USEPA's 2017 draft *Portland Harbor Superfund Site: Sampling Plan for Pre-Remedial Design, Baseline, and Long-Term Monitoring* (USEPA 2017b), which recommended pre-design sampling of SMAs on a sampling grid of approximately 150-foot centers. When using a sampling grid with 150-foot centers, the diagonal distance between data points is 212 feet. Half of that diagonal distance is 106 feet. Therefore, all points within the recommended pre-design sampling grid are within 106 feet of any historical data point (this was conservatively rounded down to 100 feet in Figure F-3).

Therefore, the current dataset has an appropriate sample density and an unbiased distribution that is more representative of the historical data coverage within the ROD SMAs and is sufficient for completion of the T4 Basis of Design.

1.2 Age of the Data

More than 100 surface sediment samples have been collected at the T4 SDU throughout the past 20 years, with the USEPA Feasibility Study (FS) dataset collected between 1997 and 2008, as listed in Table F-1. Nearly all of the historical surface sediment data are more than 10 years old, and some are more than 20 years old. Given the prevailing sedimentation rates throughout much of the T4 SDU, as well as localized areas of erosion, particularly along the berthing lanes on the north side of Slip 3, where maintenance dredging has taken place, there is a high probability that the top 30 centimeters (cm) of sediment has been partially or fully replaced or removed since those data were collected. Therefore, the historical data are no longer representative of current surface sediment conditions. As

previously mentioned, there are 91 surface sediment samples that have been collected more recently (2015 to 2019) that are more representative of the current surface sediment within the T4 SDU.

1.3 Deposition Versus Erosion/Scour Potential

Overall, a large majority of T4 is net depositional, based on bathymetric changes from 2004 to 2018 (Figure F-4). The mudline has accreted by approximately 15 to 30 cm (0.5 to 1 foot) or more in Slip 1 and Wheeler Bay. Outside of the berthing lanes, similar or higher sedimentation rates are also observed in the southern half of Slip 3. The main exceptions to the net depositional conditions at T4 are steep side-slope areas, including the northern side-slope of Slip 1; the berthing lanes in Slip 3, which are subject to localized vessel propwash; the 2015 and 2016 maintenance dredging areas in Berths 401 and 410; and the early action removal areas in Slip 3 and Berth 414.

Based on the net bathymetric change discussed in this document and depicted in Figure F-4, and the estimated net sedimentation rates shown in Figure F-5, significant sediment has accumulated at many of the historical surface sediment sample locations since their collection, or alternatively, dredging activities or propwash action have removed or redistributed sediments. As a result, the 30-cm surface sediment layer will have been covered, mixed with newly deposited sediment, or moved in the 11 to 22 years since the historical data were collected. For example, given typical sedimentation rates of 0.1 to 0.25 foot per year in Slip 1, Wheeler Bay, and the south side of Slip 3, most of these areas will have been covered by 1 to several feet of new sediment since the historical data were collected. Therefore, the historical surface sediments have been fully replaced throughout much of the T4 SDU, and the current dataset is more representative of current surface sediment conditions.

1.4 Evidence of Natural Recovery

Historical surface sediment data from T4 (1997 through 2008) were compared to the recent PDI surface sediment dataset (2015 through 2019) to determine if significant changes in sediment quality have occurred over time, in particular, decreases in surface sediment concentrations that would be indicative of natural recovery. The following two types of data comparisons were made: 1) an evaluation of historical versus recent population statistics and box plots; and 2) a pair-comparison evaluation of historical and recent data pairs tested for statistical significance using the nonparametric Wilcoxon Signed Rank Test (McDonald 2014), as recommended by USEPA in its comments dated February 25, 2020, and clarified in subsequent discussions between the Port and USEPA in April and May 2020.

1.4.1 Surface Sediment Population Comparisons

A graphical comparison of historical (1997 through 2008) and current (2018 through 2019) surface sediment concentrations for total PAHs, total PCBs, and DDx are shown in Figures F-6a, F-6b, and

F-6c, respectively, for each of the T4 subareas. T4 SDU box plot comparisons for these COCs on a site-wide basis are shown in Figure F-7. A comparison of central tendency statistics (median and mean values) for historical and current surface sediment data are summarized in Table F-2.

The aforementioned box plots and summary statistics document significant reductions in PAH, PCB, and DDx concentrations over time, indicative of ongoing natural recovery at T4. Mean total PAH concentrations decreased by 56% to 86% over the last one to two decades, depending on the subarea, with an average T4 SDU reduction of approximately 83%. Similar reductions were observed for PCBs (reductions in mean PCB concentrations of 58% to 87%, with an average T4 SDU reduction of approximately 76%). Reductions in DDx concentrations were somewhat lower, likely because of a higher percentage of undetected values, though still significant (reductions in mean DDx concentrations of 31% to 66%, with an average T4 SDU reduction of approximately 58%).

1.4.2 Surface Sediment Pair Comparisons

Historical and recent surface sediment data were paired using the approach recommended by USEPA. First, the T4 site was organized into geomorphic areas that are characterized by similar depositional environments, including the following:

- Open waterways
- Steep side-slopes, including underpier areas
- Active navigation lane and berthing areas at Berths 410 and 411

Within these geomorphic boundaries, Thiessen polygons were generated based on the historical surface sediment data distributions for total PAHs and total PCBs, as shown in Figures F-8a and F-8b. DDx and dioxins/furans were not included in this analysis due to a lack of historical exceedances (for DDx) and low historical data density (for dioxins/furans). Separate polygon mosaics were developed for total PAHs and total PCBs because of differences in sample locations and densities in the historical datasets for these chemical groups. Then, the historical sample within each polygon was paired with the closest recent sample within the same polygon. Because some polygons contained multiple recent data points, and a few polygons had no recent data, approximately half of the historical and recent data were captured in the data pairs. Because of uncertainties associated with location control (affecting both spatial coordinates and mudline elevations on steep side-slopes with restricted access), underpier samples could not be reliably paired and were excluded from the analysis.

Scatterplots of historical and recent data pairs are shown in Figure F-9. A large majority of the recent data exhibit lower concentrations compared to their historical counterpart, as evidenced by a preponderance of data falling below the 1-to-1 correlation line. Specifically, 82% of the total PAH data (40 of 49 samples) and 92% of the total PCB data (35 of 38 samples) are lower than their

historical counterpart. The concentration reductions are significant and are often one to two orders of magnitude lower.

Summary statistics for the historical-recent data pairs are shown in Table F-3. Site-wide, the median and mean total PAH concentrations have decreased by 90% and 79%, respectively, and median and mean total PCB concentrations have decreased by 91% and 89%, respectively. Similar reductions were observed in the various T4 subareas, with the largest reductions occurring in Slip 1. The reductions in central tendency statistics for the data pairs are very similar to the reductions observed in population statistics (compare Tables F-2 and F-3), the net result being approximate order-of-magnitude reductions in both total PAHs and total PCBs over the last 10 to 20 years since the historical data were collected.

The historical-recent data pairs were subjected to the nonparametric Wilcoxon Signed Rank Test to determine whether statistically significant reductions have occurred. Wilcoxon summary statistics are shown in Table F-4. On a site-wide basis, concentrations of total PAHs and total PCBs are decreasing with greater than 99.9% confidence. In T4 subareas, statistical significance levels are somewhat reduced because of lower numbers of data pairs. Nevertheless, evidence for total PAH and total PCB concentration reductions are evident in all subareas, with greater than 99% confidence in Slips 1 and 3, and greater than 80% to 90% confidence in Berth 414 and Wheeler Bay, respectively.

1.4.3 Summary of Sediment Quality Changes Over Time

Significantly decreasing sediment concentrations at T4 are corroborated by both population-based and pair-comparison statistics. In particular, site-wide pair-comparison statistics show 79% to 90% reductions for PAHs and 89% to 91% reductions for PCBs for the arithmetic mean and median, respectively. These reductions are statistically significant at a very high level of confidence. Similar reductions are observed in all T4 subareas.

The observed reductions are consistent with generally high sedimentation rates at T4, combined with the Port's ongoing source control efforts, and provide further evidence that historical data are not representative of current conditions. Based on these comparisons, it is expected that the extent of remedial action level (RAL) exceedances and the size of the SMAs at T4 will be reduced relative to the historical dataset.

1.5 Heterogeneity of Substrate

Historical and recent grain size distributions (expressed as percent fines, including silt and clay) are presented in Figure F-10. The recent grain size data indicate a prevalence of fine-grained material in the deeper waters of Slip 1 and Wheeler Bay, both of which are inactive, with fines content greater than 80%. Both areas are also highly depositional (Figure F-5). Outside of the active navigation lane at Berths 410 and 411, the southern half of Slip 3 generally contains a moderate amount of fines

(36% to 55%) and is also highly depositional. In contrast, coarser-grained sediments are present in the Berths 410 and 411 navigation lane, with fines content typically less than 20%, and is disturbed by propwash from vessel docking/undocking and periodic maintenance dredging. Coarser-grained sediments are also typically observed on terminal side-slopes, including underpier areas, many of which are partially armored with riprap. The historical grain size data exhibit similar distribution patterns, although they are confounded by multiple, disparate investigations and sampling methods and thus exhibit greater spatial variability. In general, the nature of the maritime operations, structures, and geomorphology at T4 have not changed significantly over the last few decades; therefore, sedimentary dynamics and substrate characteristics appear to be relatively stable over time.

1.6 Presence of Outliers

The historical and current surface sediment dataset identified localized surface sediment containing higher concentrations for specific contaminants than compared to other surface sediment samples surrounding these localized sediments. For purposes of this evaluation, these surface sediment samples are considered outliers for both datasets when comparing central tendencies (median and mean values) in Section 1.4. For example, one outlier sample in particular (historical sample T4-VC13, collected in 2004) on the southeast slope of Slip 1 exceeded the PCB RAL over 13-fold. The location of this outlier PCB sample was reoccupied in the PDI (sample SG43), and in addition, five closely spaced offset surface sediment samples were collected to further delineate this localized PCB exceedance (samples SG42, SG44, SG45, SG46, and SG47). The historical PCB exceedance was not confirmed in the PDI. There were no RAL exceedances in any of the six samples dedicated to further characterizing this historical outlier. Therefore, the outlier was evidently a sampling or laboratory artifact was so small that it could not be replicated.

In the current dataset, the main location of outlier concentrations is the underpier area beneath Berth 411. This is the historical source area associated with former pencil pitch handling and spills and contains PAH and PCB concentrations above the RAL threshold by many folds, especially toward the head of the slip. It is physically separated from most of the Slip 3 basin by a sheetpile wall, resulting in limited exchange of sediments between the underpier area and the adjacent berth. The sheetpile wall was installed in 2004 from a minimum tip elevation of -80 feet Columbia River Datum (CRD) to a pile cutoff elevation of -20 feet CRD. Following maintenance dredging in 2017, sediments adjacent to the sheetpile wall were at or below -40 feet CRD (Hart Crowser 2018). The underpier area beneath Berth 411 will be addressed as a separate remediation area and will likely require a unique remediation approach. It was characterized in detail in the PDI by diver-assisted surface grab samples and cores that will be used to represent current conditions and supersede historical data, as well as to support RD.

2 Conclusions

Based on multiple lines of evidence, the historical surface sediment dataset is no longer representative of the surface sediment quality in the deep-water areas of the T4 SDU. These lines of evidence include the following:

- The 2019 PDI surface sediment data were sampled on an unbiased, systematic grid on approximately 150-foot centers, which in combination with other recent data collected from 2015 through 2018, provides sufficient coverage and data density to support the Basis of Design.
- Given the prevailing sedimentation rates throughout much of T4 (0.1 to 0.25 foot/year), approximately 1 to several feet of sediment would have accumulated since the historical data were collected 11 to 22 years ago, thus fully replacing the 1-foot surface sediment interval.
- The nature of the maritime operations, structures, and geomorphology at T4 have not changed significantly over the last few decades; as a result, the nature and extent of depositional and erosional processes and environments at T4 have been relatively stable and consistent over time.
- The primary historical outlier location (PCB RAL exceedance at T4-VC13) was reoccupied and not confirmed during the PDI; in fact, this location and surrounding offset locations were all below RALs.
- Significantly decreasing sediment concentrations at T4 are corroborated by both population-based and pair-comparison statistics. In particular, site-wide pair-comparison statistics show 79% to 90% reductions for PAHs and 89% to 91% reductions for PCBs for the arithmetic mean and median, respectively. These reductions are statistically significant at a very high level of confidence. Similar reductions are observed in all T4 subareas, providing evidence of ongoing natural recovery throughout the site.

Due to its unique characteristics, the appropriate use of historical data in side-slope areas for SMA delineation was further evaluated on a case-by-case basis considering the age and quality of the side-slope data, the prevailing sedimentation (or erosion) rates, and the availability and proximity of more recent PDI samples. This case-by-case analysis is summarized in Tables F-5 and F-6. Side-slope areas are generally characterized by relatively high rates of deposition (south slopes of Slips 1 and 3) and moderate to high rates of erosion (north slopes of Slips 1 and 3 and mainstem-facing slopes at Berths 401 and 414; Figure F-4). Side-slope samples that exhibit more than 1 foot of erosion or deposition since they were collected were excluded from consideration because they are no longer representative of current surface sediment conditions at T4 (Table F-5). The remaining side-slope samples were further evaluated based on their age, data quality, proximity to PDI samples, and influence on the surface SMA (i.e., RAL exceedances) (Table F-6). None were considered appropriate for use in remedial design because of their age (collected in 1997 through 2004), questionable

location and water depth control, available of nearby PDI data in most cases, and lack of influence on the surface SMA (i.e., concentrations below RALs).

In conclusion, for the purpose of SMA delineation, the current surface sediment dataset is a better representation of the current surface sediment conditions at T4 and is most appropriate for use in remedial design. The data density of surface sediment data within SMAs will be revisited during remedial design, and additional surface data may be collected in some areas.

3 References

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Hart Crowser, 2018. *Analytical Results on Post-Dredge Samples*. Terminal 4 Berth 410. Prepared for the Port of Portland. January 3, 2018.

McDonald, J.H., 2014. *Handbook of Biological Statistics*. Third Edition. Baltimore: Sparky House Publishing; p. 299. Available at: www.biostathandbook.com.

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USEPA, 2017b. *Portland Harbor Superfund Site: Sampling Plan for Pre-Remedial Design, Baseline, and Long-Term Monitoring*. Revised Working Draft. June 6, 2017.

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Tables

Table F-1
Surface Sediment Data in USEPA FS Database

Data Collection Event	Reference	Dates of Collection		No. of Sample Locations
Portland Harbor Sediment Investigation	Weston 1998	9/18/1997	10/17/1997	10
Port of Portland Terminal 4 Remedial Investigation	Hart Crowser 2000	10/12/1998	10/15/1998	23
City outfall sediment investigations	CH2M Hill 2004	10/15/2002	10/15/2002	5
Round 1 co-located surface sediment	Integral 2004	10/24/2002	10/24/2002	1
Terminal 4 Early Action EE/CA Report	BBL 2005	3/3/2004	4/21/2004	42
Round 2a beach sediment composites	Integral 2005	7/28/2004	7/28/2004	3
Round 2a sediment grabs	Integral 2005	8/13/2004	8/13/2004	1
2005 Portland District O&M Dredge Sediment Characterization	Tetra Tech 2006	5/26/2005	5/26/2005	3
Round 2b benthic sediment	Integral and Windward 2006	12/14/2005	12/16/2005	4
Terminal 4 Anchor Appendix G Sediment Data	Anchor Environmental 2008	7/19/2006	12/13/2007	9
Terminal 4 Abatement Phase 1 – Construction Phase 1 – Dredging and Capping	Anchor QEA 2009	12/29/2008	12/30/2008	17

Notes:
EE/CA: Engineering Evaluation and Cost Analysis
O&M: operation and maintenance

Table F-2

T4 Summary Statistics by Subarea

Subarea	Sample Count		Median			Arithmetic Mean		
	Historical	Current	Historical	Current	Percent Reduction	Historical	Current	Percent Reduction
Total PAH (U = 1/2) (µg/kg)								
Berth 401	5	6	730	465	36.3%	1,418	551	61.1%
Slip 1	35	40	5,300	367	93.1%	10,758	1,523	85.8%
Wheeler Bay	19	14	3,000	960	68.0%	21,864	3,279	85.0%
Slip 3[1]	39	26	42,000	4,350	89.6%	67,153	14,168	78.9%
Berth 414	13	9	7,500	1,600	78.7%	12,565	5,573	55.6%
T4 Site-Wide[1]	111	95	8,790	980	88.9%	32,264	5,565	82.8%
Total PCBs (Combined Aroclors and Congeners, U = 1/2) (µg/kg)								
Berth 401	6	6	29.5	8.3	71.8%	31.2	13.1	58.0%
Slip 1	33	40	39.0	1.9	95.0%	79.5	23.8	70.1%
Wheeler Bay	10	14	39.5	6.6	83.2%	46.4	7.9	83.0%
Slip 3[1]	11	26	29.0	3.5	88.0%	34.8	4.5	87.1%
Berth 414	8	9	41.5	7.5	81.9%	34.4	5.9	82.9%
T4 Site-Wide[1]	68	95	37.0	4.8	87.0%	57.8	13.8	76.1%
Total DDx (U = 1/2) (µg/kg)								
Berth 401	5	3	6.2	3.1	50.6%	10.4	3.7	64.6%
Slip 1	31	4	7.4	7.0	6.1%	11.7	8.1	30.8%
Wheeler Bay	10	6	10.5	5.1	51.9%	13.7	5.2	62.5%
Slip 3[1]	14	7	9.5	3.2	66.1%	12.3	4.5	63.3%
Berth 414	8	7	11.0	5.1	53.6%	17.2	5.8	66.1%
T4 Site-Wide[1]	68	27	10.0	5.1	49.0%	12.7	5.4	57.5%

Notes:
1. Excludes Pier 4 underpier data
µg/kg: micrograms per kilogram
DDx: the sum of DDT, DDD, and DDE
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl

Table F-3

Paired Summary Statistics by Subarea

Subarea	Pair Count[1]	Median			Arithmetic Mean		
		Historical	Current	Percent Reduction	Historical	Current	Percent Reduction
Total PAHs (U = 1/2) (µg/kg)							
Slip 1	13	11,000	396	96.4%	19,393	1,294	93.3%
Wheeler Bay	8	3,200	959	70.0%	23,288	2,464	89.4%
Slip 3	20	35,500	5,215	85.3%	65,532	16,819	73.5%
Berth 414	7	2,800	1,593	43.1%	17,169	2,661	84.5%
T4 Site-Wide	49	14,000	1,360	90.3%	37,433	8,001	78.6%
Total PCBs (U = 1/2) (µg/kg)							
Slip 1	13	70	1	97.9%	148	13	91.3%
Wheeler Bay	6	59	7	88.7%	53	10	80.9%
Slip 3	13	29	3	89.2%	37	5	87.4%
Berth 414	5	7	1	89.2%	5	1	84.1%
T4 Site-Wide	38	49	4.6	90.6%	78	8.3	89.4%

Notes:
1. Excludes under-pier samples
µg/kg: micrograms per kilogram
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
T4: Terminal 4

Table F-4
Wilcoxon Signed Rank Test Comparison Results

Subarea	Pair Count	Test Statistic (V)	p-Value	Significance Level
Total PAHs (U = 1/2) (µg/kg)				
Slip 1	13	88	0.001	>99%
Wheeler Bay	8	31	0.078	>90%
Slip 3	20	184	0.002	>99%
Berth 414	7	23	0.156	>80%
T4 Site-Wide	49	1114	4.45E-08	>99%
Total PCBs (U = 1/2) (µg/kg)				
Slip 1	13	82	0.008	>99%
Wheeler Bay	6	20	0.063	>90%
Slip 3	13	88	0.001	>99%
Berth 414	5	15	0.063	>90%
T4 Site-Wide	38	702	5.52E-08	>99%

Notes:
µg/kg: micrograms per kilogram
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
T4: Terminal 4

Table F-5
Historical Side Slope Samples

Site Subarea	Location Description	Station ID (from USEPA Database)	Location ID	Year Collected	Elevation Change Since Sampled (feet)
Berth 401	Berth 401 underpier – downstream	WLCT4C04UP01	T4-UP01	2004	-7.1
Berth 401	Berth 401 side-slope	LW2-GBT007	BT007	2005	-1.3
Berth 401	Berth 401 underpier/ side-slope	WLCT4C04UP02	T4-UP02	2004	-11.93
		WLCT4C04VC03	T4-VC03	2004	-1.03
Slip 1	Berth 405 underpier	WLCT4C04UP03	T4-UP03	2004	-1.14
		WLCT4C04UP04	T4-UP04	2004	-1.46
		WLCT4C04UP05	T4-UP05	2004	3.87
Slip 1	Side-slope cluster at head of slip (north)	WLCT4C04VC10	T4-VC10	2004	-0.12
		WLCOFJ0252C04	52C04	2002	10
		WLCOFJ0252C01	52C01	2002	11.19
		LW2-B010	B010	2004	-7.6
		WLCOFJ0252C02	52C02	2002	7.93
		WLCOFJ0252C03	52C03	2002	10.74
		WLCOFJ0252C05	52C05	2002	12.36
Slip 1	Side slope cluster at head of slip (south)	LWG0104R003SDS015C00	04R003	2002	-1.2
		WLCT4C04VC16	T4-VC16	2004	0.95
Slip 1	Berth 408 underpier – near head of slip	WLCT4C04UP08	T4-UP08	2004	3.79
Slip 1	Berth 408 underpier	WLCT4C04UP07	T4-UP07	2004	-0.81
		WLCT4C04UP06	T4-UP06	2004	2.67
Slip 1	Outer Slip 1 side-slope	WLCT4C04VC13	T4-VC13	2004	2.76
Wheeler Bay	Wheeler Bay side-slope	WR-WSI98SD025	SD025	1997	-0.6
		WLCT4J98HCS41	HC-S-41	1998	-0.24
		LW2-B011	B011	2004	-2.96
		WLCT4C04VC18	T4-VC18	2004	-0.76
Slip 3	Berth 410 underpier	WLCT4C04UP10	T4-UP10	2004	-0.44
Slip 3	Berths 410 and 411 underpier	WLCT4C04UP12	T4-UP12	2004	Unknown
		WLCT4C04UP13	T4-UP13	2004	-2.4
Slip 3	Side-slope at head of slip	WLCT4J98HCS04	HC-S-04	1998	2.87
		WR-WSI98SD033	SD033	1997	1.95
Slip 3	Pier 5 underpier	WLCT4C04UP14	T4-UP14	2004	1.4
Berth 414	Berth 414 side-slope	WLCT4G06T4PI09	T4-PI-09	2006	-2.85
		LW2-GBT010	BT010	2005	-3.64

Note:
USEPA: U.S. Environmental Protection Agency

Table F-6
Data Replacement Evaluation of Historical Side Slope Samples

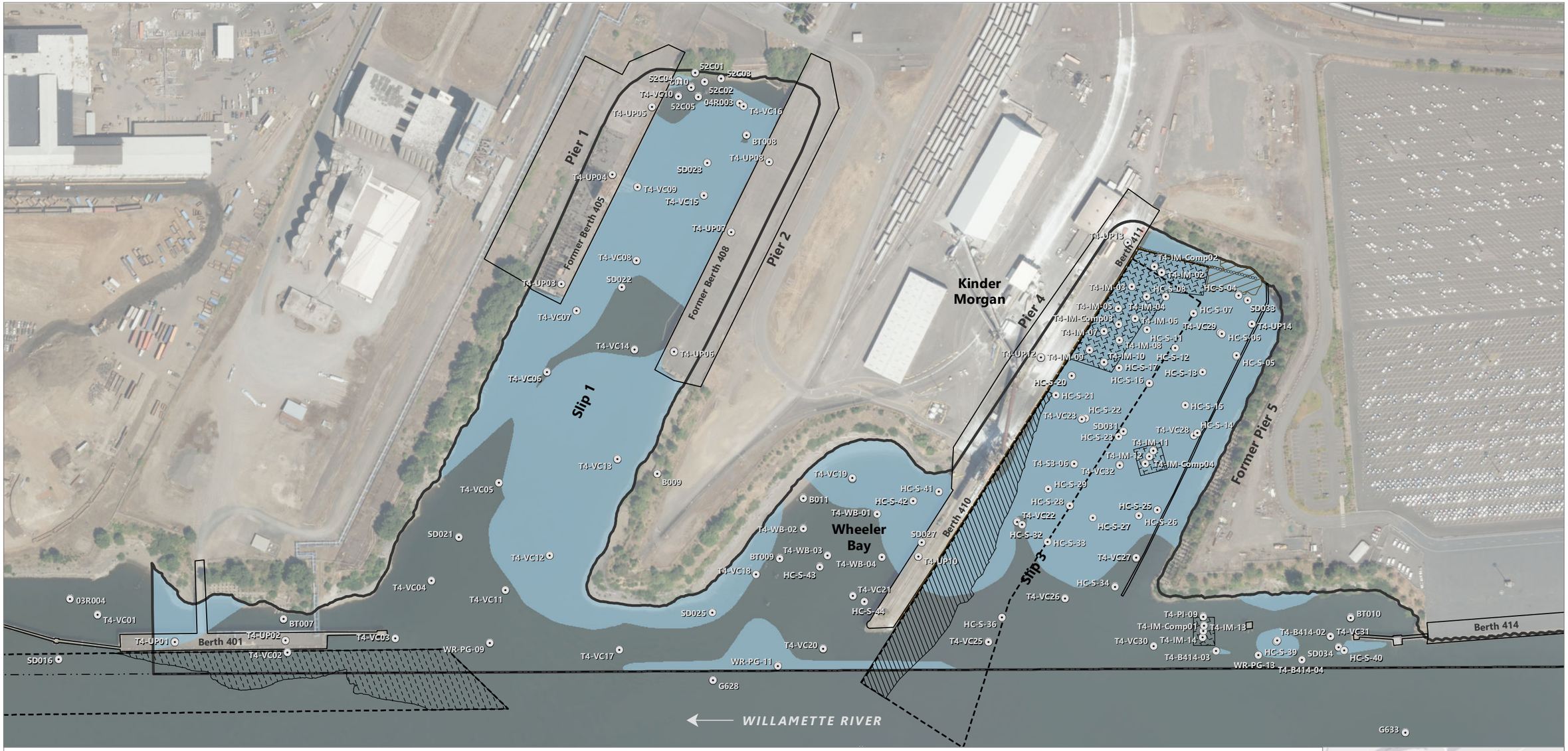
Site Subarea	Location Description	Historical Location ID	Year Collected	Closest PDI/Pre-RD Group Location	Distance from PDI location (feet)	Elevation Change Since Sampled (feet)	Historical Total PAH Concentration (ppb)	PDI Total PAH Concentration (ppb)	Historical Total PCB Concentration (ppb)	PDI Total PCB Concentration (ppb)	Use Data for SMA Delineation?	Rationale
Slip 1	Side-slope cluster at head of slip (north)	T4-VC10	2004	T4-PDI2019-SG61	approx 50	-0.12	64 JT	7,700 JT	10 UT	88.7 JT	No	This sample is not used for SMA delineation because of the age of the data and because a PDI sample (SG61) is located approximately 50 feet away. Including or excluding this sample would not affect the delineation of the SMA. The areas within these historical samples will be revisited in the BODR to further evaluate information from the PDI and other information to represent current conditions.
Slip 1	Side-slope cluster at head of slip (south)	T4-VC16	2004	T4-PDI2019-SG54	16	0.95	56,000 T	1,460 JT	150 T	15.8 JT	No	PDI station SG54 collected in 2019, which is located approximately 16 feet away from T4-VC16, is more representative of current conditions given the age of the historical data and the nearly 1 foot of net deposition that has occurred since the sample was collected.
Slip 1	Berth 408 underpier	T4-UP07	2004	T4-PDI2019-SG40	60	-0.81	19,000 T	52 JT	88 JT	0.18 JT	No	Two PDI stations collected within 60 feet of this station in 2019, SG40 and SG38, are more representative of current conditions given the age of the historical data and the 0.81 foot of net erosion that has occurred since the sample was collected.
Wheeler Bay	Wheeler Bay side-slope	SD025	1997	B107	approx 100	-0.6	2,300 T	799 JT	--	6.18 JNT	No	This sample will not be used for SMA delineation due to its age because a Pre-RD sample (B107) is located within 100 feet of this location and because this data point was sampled 23 years ago and likely does not represent current conditions. The areas within these historical samples will be revisited in the BODR to further evaluate information from the PDI and other information to represent current conditions.
		HC-S-41	1998	T4-PDI2019-SG28	approx 70	-0.24	180,000 T	11,000 JT	--	0.44 JT	No	This sample will not be used for SMA delineation due to its age because a PDI sample (SG28) is located approximately 70 feet away and because this data point was sampled 22 years ago and likely does not represent current conditions. The historical PAH RAL exceedance in this area will be revisited in the BODR. The areas within these historical samples will be revisited in the BODR to further evaluate information from the PDI and other information to represent current conditions.
		T4-VC18	2004	T4-PDI2019-SG33	2.2	-0.76	2,600 T	3,700 JT	68 T	23.4 JT	No	PDI station SG33 collected in 2019, which is located approximately 2 feet away from T4-VC18, is more representative of current conditions given the age of the historical data and the nearly 1 foot of net erosion that has occurred since the sample was collected.
Slip 3	Berth 410 underpier	T4-UP10	2004	T4-PDI2019-SG27	approx 80	-0.44	6,900 T	1,800 JT	40 JT	1.81 JT	No	This sample is not used for SMA delineation because of the age of the data and because a PDI sample (SG27) is located approximately 80 feet away. Including or excluding this sample would not affect the delineation of the SMA. The areas within these historical samples will be revisited in the BODR to further evaluate information from the PDI and other information to represent current conditions.
Slip 3	Berths 410 and 411 underpier	T4-UP12	2004	T4-PDI2019-SG24	45	Unknown	140,000 JT	49,000 JT	33 T	73.1 JT	No	This sample will not be used for SMA delineation because of the age of the data and no mudline elevation is included in the database. PDI station SG24, which is located approximately 45 feet away, is more representative of current conditions.

Table F-6
Data Replacement Evaluation of Historical Side Slope Samples

Notes:
-- Not available
JT: Estimated value (calculated result)
T: Calculated or averaged result
UT: Compound analyzed for but not detected above detection limit (calculated result)

BODR: Basis of Design Report
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
PDI: pre-remedial design investigation
ppb: parts per billion
RAL: remedial action level
SMA: sediment management area

Figures



LEGEND:

- Sediment Decision Unit RM 4.5E
- Navigation Channel
- Shoreline Structures
- Sheet Pile Wall
- Timber Pinch Pile
- ROD SMAs (USEPA 2017)
- Potential Maintenance Dredging
- Berth 410 Maintenance Dredging (2017)
- Berth 401 Maintenance Dredging (2015)
- Terminal 4 Early Action Dredging (2008)
- Early Action Sediment Cap
- Historical Surface Sediment Sample Location

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 1991) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. Surface sediment locations are from the USEPA FS Database.
5. SDU boundary extends approximately 1,000 feet upstream from the extent shown.
6. Sample intervals dredged during 2008 early action remediation were removed from analyses.
7. SMAs are shown only within the Portland Harbor RI/FS Study Area Boundary (below +13 feet NAVD88).

0 250
Feet

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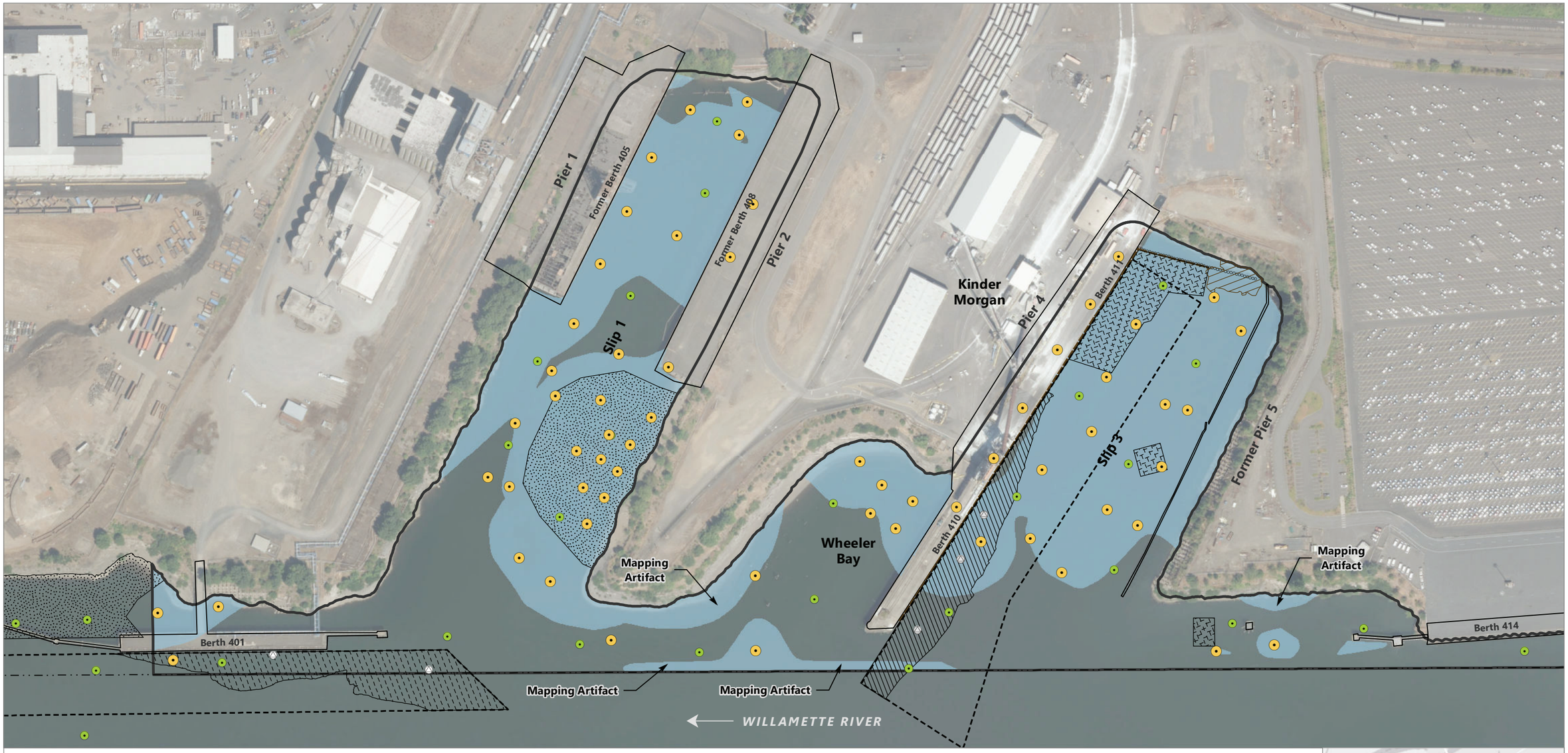
Figure F-1
Historical Surface Sediment Sample Locations
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy



LEGEND:

- Sediment Decision Unit RM 4.5E
- Navigation Channel
- Shoreline Structures
- Sheet Pile Wall
- Timber Pinch Pile
- ROD SMAs (USEPA 2017b)
- Potential Maintenance Dredging
- Berth 410 Maintenance Dredging (2017)
- Berth 401 Maintenance Dredging (2015)
- Terminal 4 Early Action Dredging (2008)
- Early Action Sediment Cap
- Total PCBs Surface PTW
- Berths 401 and 410 Surface Sediment Sample Location
- Pre-RD Group Surface Sediment Sample Location
- PDI Surface Sediment Sample Location

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 1991) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. SDU boundary extends approximately 1,000 feet upstream from the extent shown.
5. Berth 410 and Berth 401 surface samples are not included in the USEPA FS Database.
6. SMAs are shown only within the Portland Harbor RI/FS Study Area Boundary (below +13 feet NAVD88).

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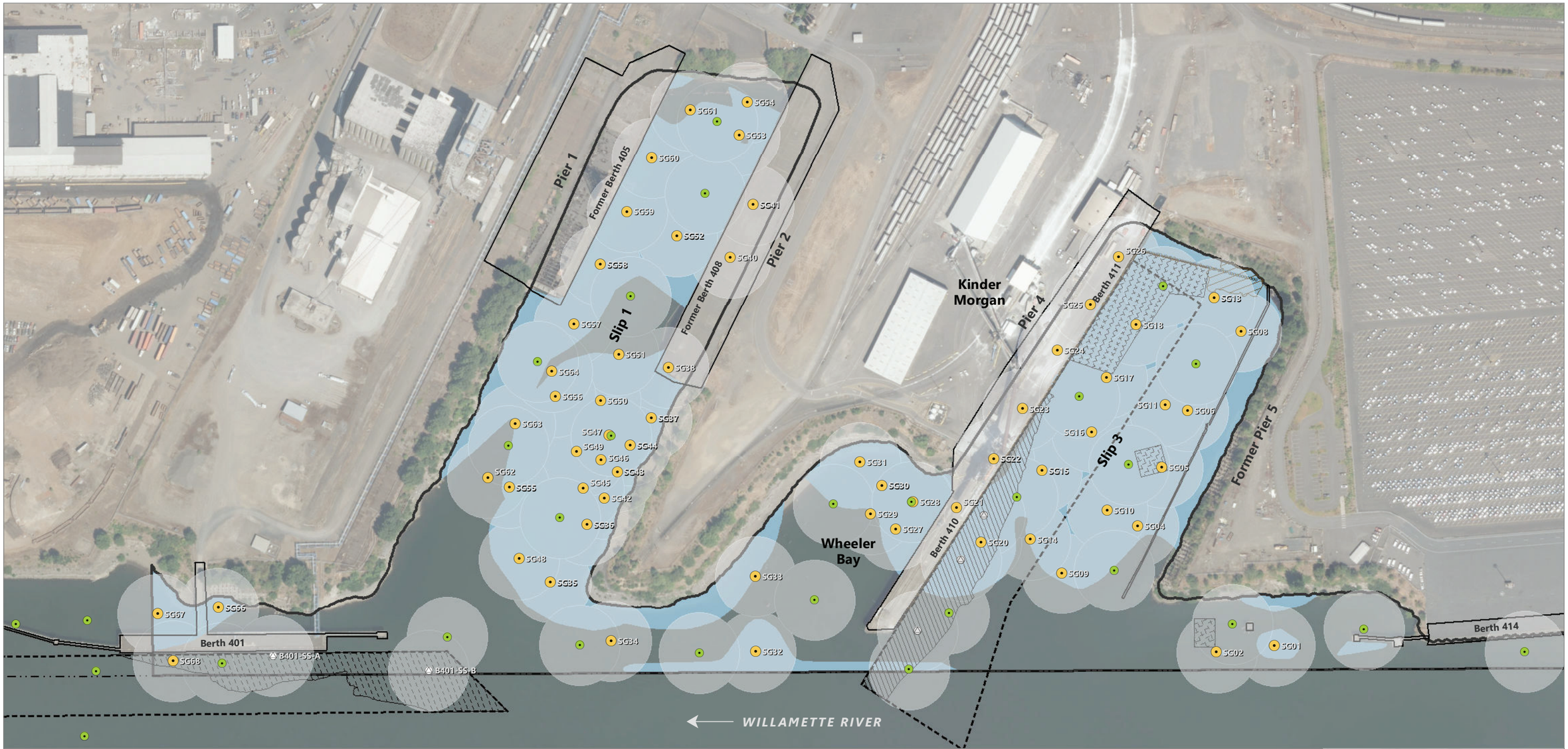
Figure F-2
Current Surface Sediment Sample Locations
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy



LEGEND:

- Sediment Decision Unit RM 4.5E
- Navigation Channel
- Shoreline Structures
- Sheet Pile Wall
- Timber Pinch Pile
- ROD SMAs (USEPA 2017)
- Potential Maintenance Dredging
- Berth 410 Maintenance Dredging (2017)
- Berth 401 Maintenance Dredging (2015)
- Terminal 4 Early Action Dredging (2008)
- Early Action Sediment Cap
- 100-Foot Buffer (Pre-RD andPDI Locations)
- Berths 401 and 410 Surface Sediment Sample Location
- Historical Surface Sediment Sample Location
- PDI Surface Sediment Sample Location
- Pre-RD Group Surface Sediment Sample Location

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 1991) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. Historical surface sediment locations are from the USEPA FS Database.
5. SDU boundary extends approximately 1,000 feet upstream from the extent shown.
6. Berth 410 and Berth 401 surface samples are not included in the USEPA FS Database.
7. Sample intervals dredged during 2008 early action remediation were removed from analyses.
8. SMAs are shown only within the Portland Harbor RI/FS Study Area Boundary (below +13 feet NAVD88).
9. Pre-RD Group data were collected by Geosyntec Consultants in 2018.

0 250
Feet

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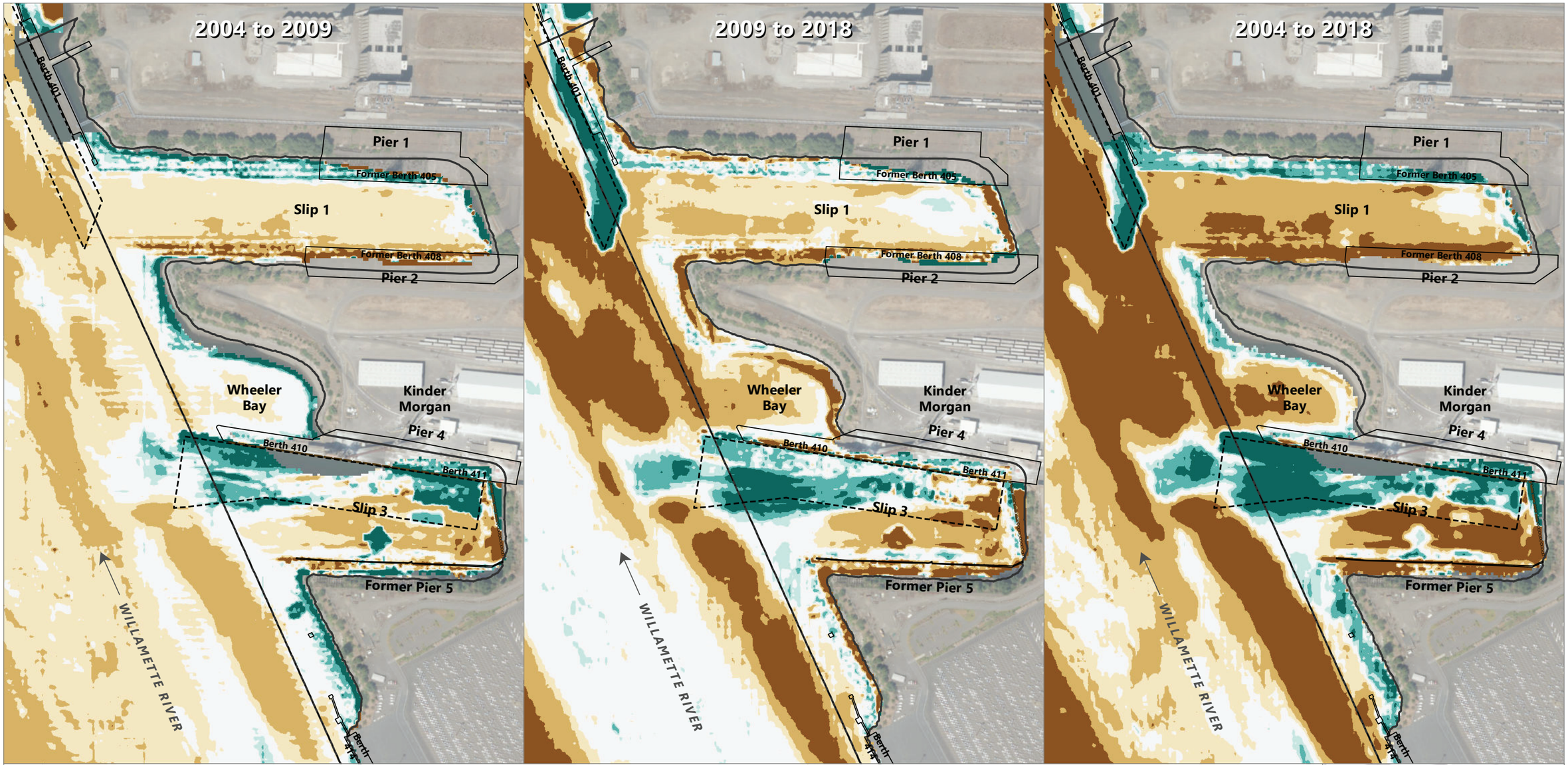
Figure F-3
Data Distribution Map
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy



LEGEND:

- Sediment Decision Unit RM 4.5E
- Navigation Channel
- Shoreline Structures
- Sheet Pile Wall
- Timber Pinch Pile
- Potential Maintenance Dredging
- Berth 410 Maintenance Dredging (2017)
- Berth 401 Maintenance Dredging (2015)
- Terminal 4 Early Action Dredging (2008)
- Early Action Sediment Cap

Bathymetric Change (feet)

- < -2
- -1.99 - -1
- -0.99 - -0.5
- -0.49 - 0.5
- 0.51 - 1
- 1.01 - 2
- > 2

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 1991) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. SDU boundary extends approximately 1,000 feet upstream from the extent shown.
5. Bathymetric surveys performed by David Evans and Associates.
6. Bathymetry for 2004 and 2009 has a 1-meter resolution. Bathymetry for 2018 has a 3-foot resolution.

0 400
Feet

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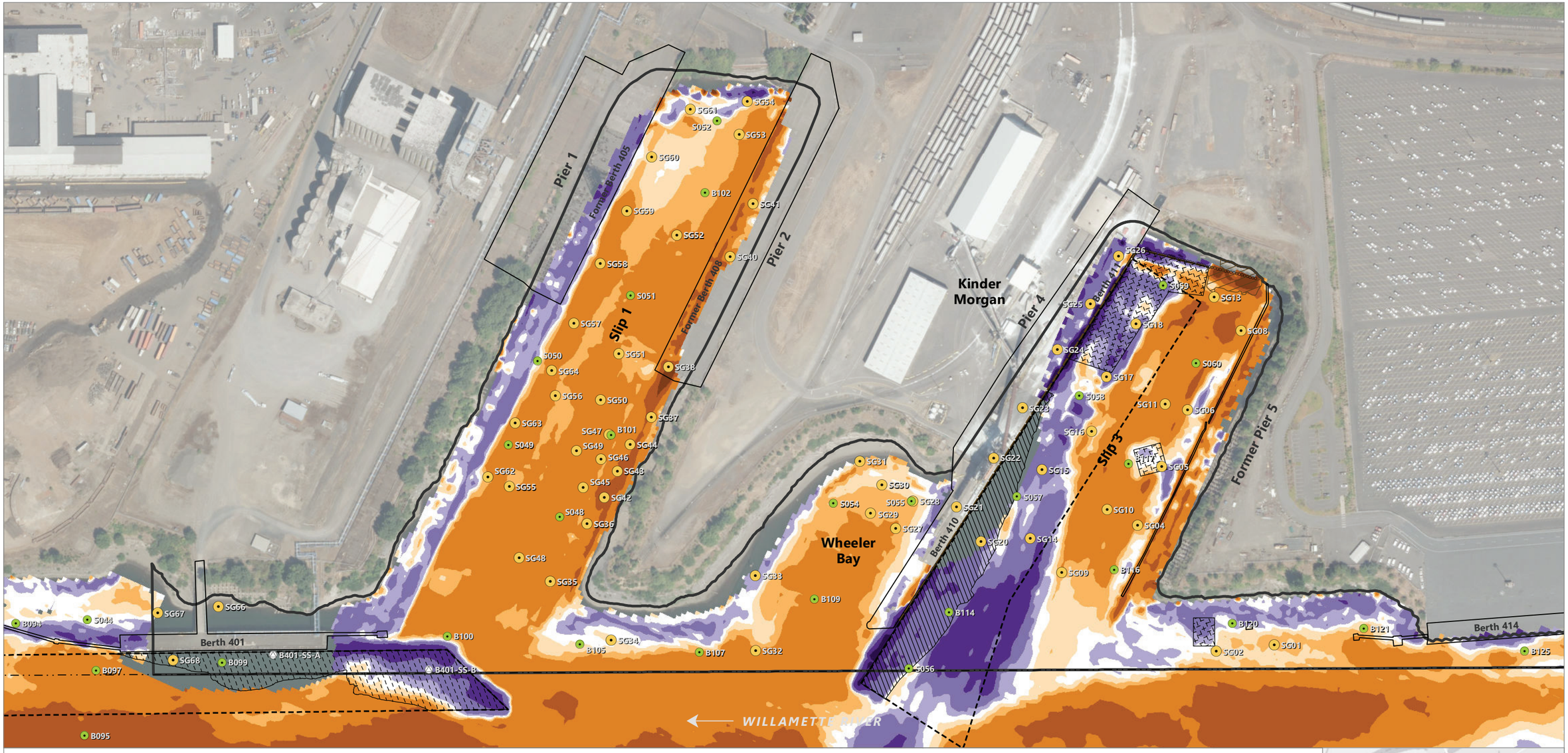
Figure F-4
Net Bathymetric Change
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy



LEGEND:

- Sediment Decision Unit RM 4.5E
- Navigation Channel
- Shoreline Structures
- Sheet Pile Wall
- Timber Pinch Pile
- Potential Maintenance Dredging
- Berth 410 Maintenance Dredging (2017)
- Berth 401 Maintenance Dredging (2015)
- Terminal 4 Early Action Dredging (2008)
- Early Action Sediment Cap
- Berths 401 and 410 Surface Sediment Sample Location
- Surface Sediment Sample Location

Net Sedimentation Rate (feet/year)

< -0.5	0.01 - 0.05
-0.49 - -0.25	0.06 - 0.1
-0.24 - -0.1	0.11 - 0.25
-0.09 - -0.05	0.26 - 0.5
-0.04 - 0	> 0.5

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 1991) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. Surface sediment locations are from the USEPA FS Database.
5. SDU boundary extends approximately 1,000 feet upstream from the extent shown.
6. Berth 410 and Berth 401 surface samples are not included in the USEPA FS Database.
6. Sample intervals dredged during 2008 early action remediation were removed from analyses.
7. SMAs are shown only within the Portland Harbor RI/FS Study Area Boundary (below +13 feet NAVD88).
8. Bathymetric survey performed by David Evans and Associates.
9. Bathymetry for 2004 has a 1-meter resolution. Bathymetry for 2018 has a 3-foot resolution.

0 250
Feet

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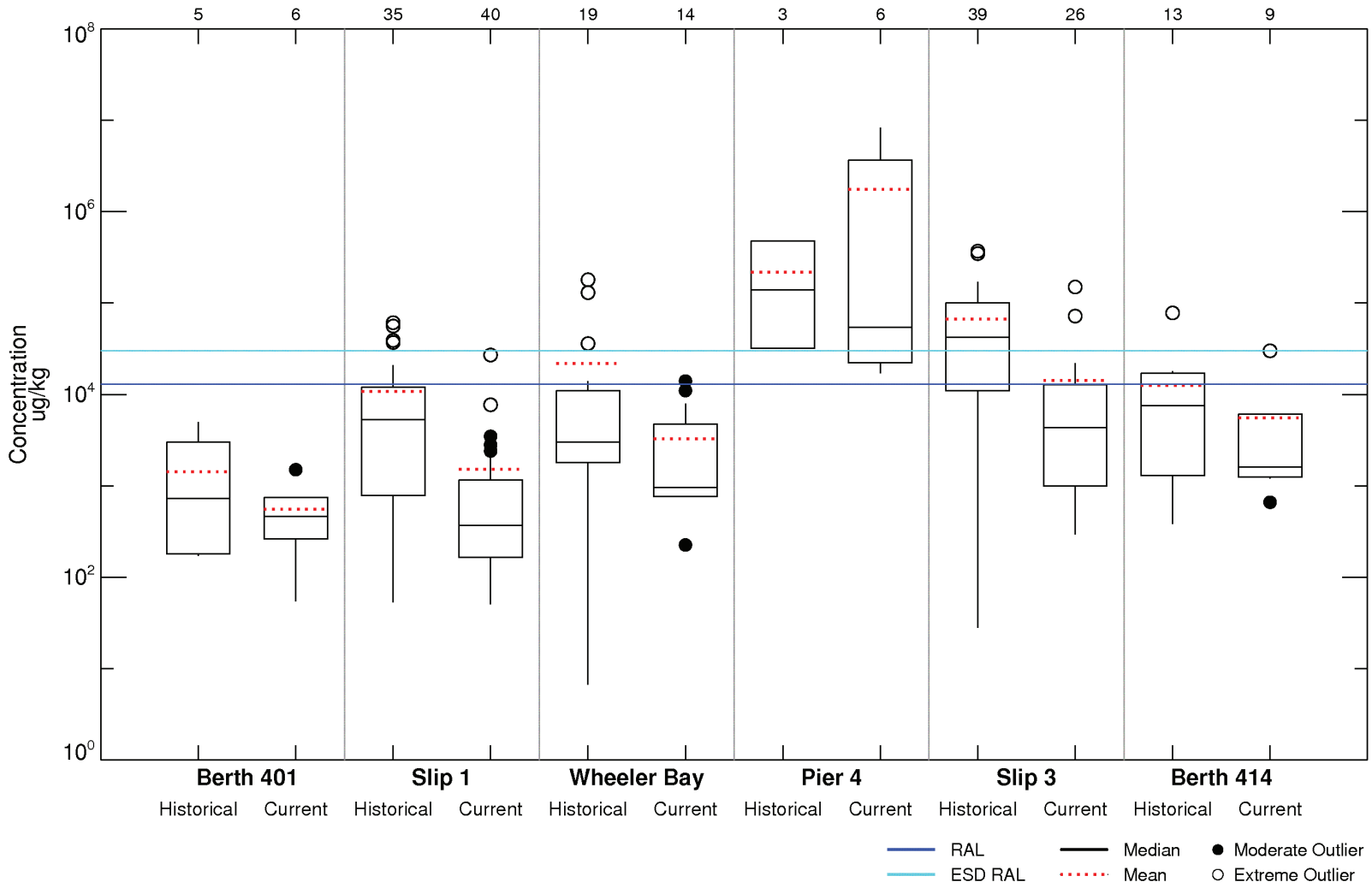
Figure F-5
Net Sedimentation Rate Change – 2004 to 2018
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy



Notes:
- Sample counts displayed at top of each box plot.
- Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data are within the box boundaries. The whiskers represent the remaining data minus the outliers. The moderate outlier value is greater than the third quartile plus 1.5×IQR or less than the first quartile minus 1.5×IQR. The extreme outlier value is greater than the third quartile plus 3.0×IQR or less than the first quartile minus 3.0×IQR.

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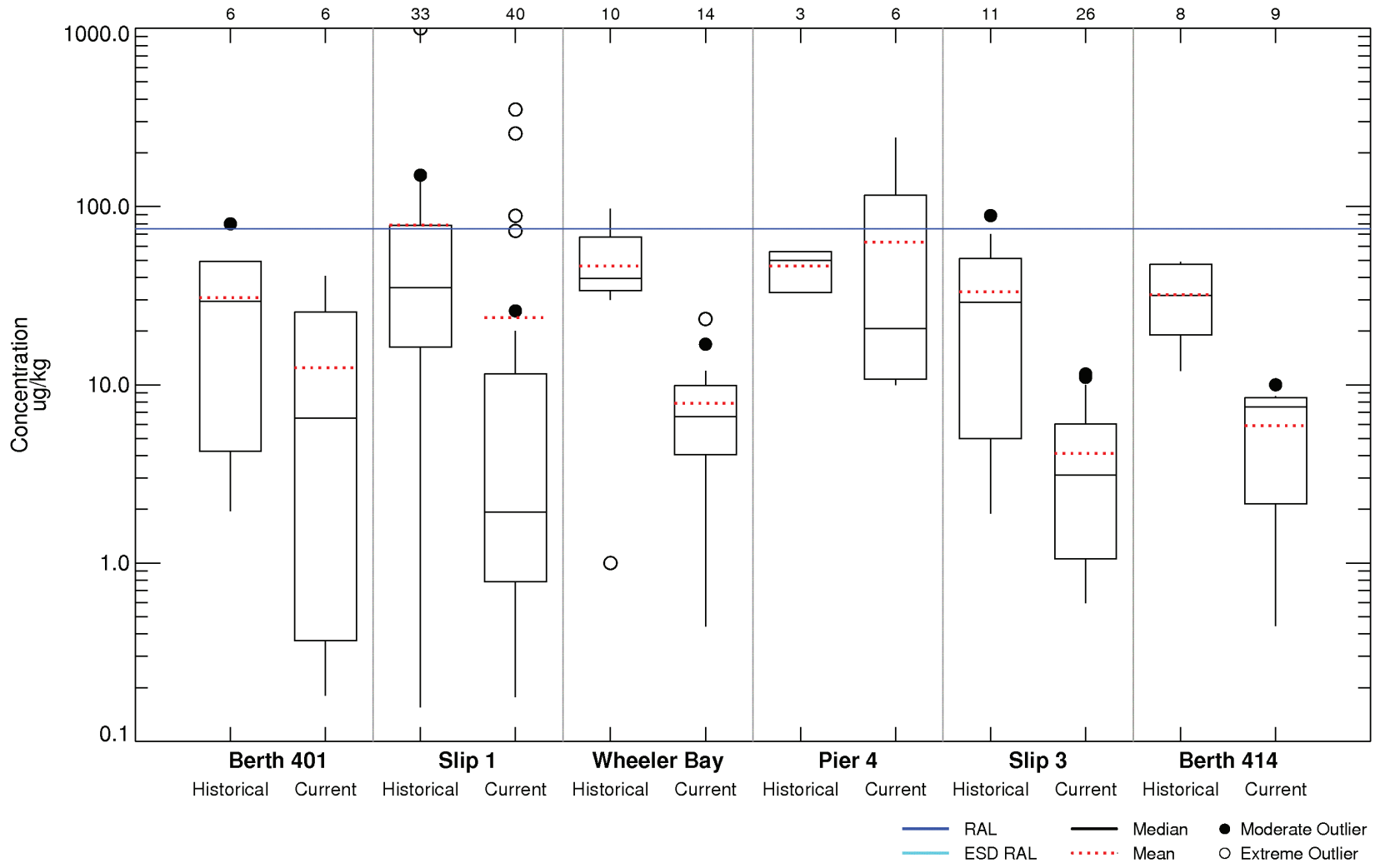
Figure F-6a
Historical Versus Current Data Comparison by Subarea: Total PAHs (U=1/2)



Notes:
- Sample counts displayed at top of each box plot.
- Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data are within the box boundaries. The whiskers represent the remaining data minus the outliers. The moderate outlier value is greater than the third quartile plus 1.5×IQR or less than the first quartile minus 1.5×IQR. The extreme outlier value is greater than the third quartile plus 3.0×IQR or less than the first quartile minus 3.0×IQR.

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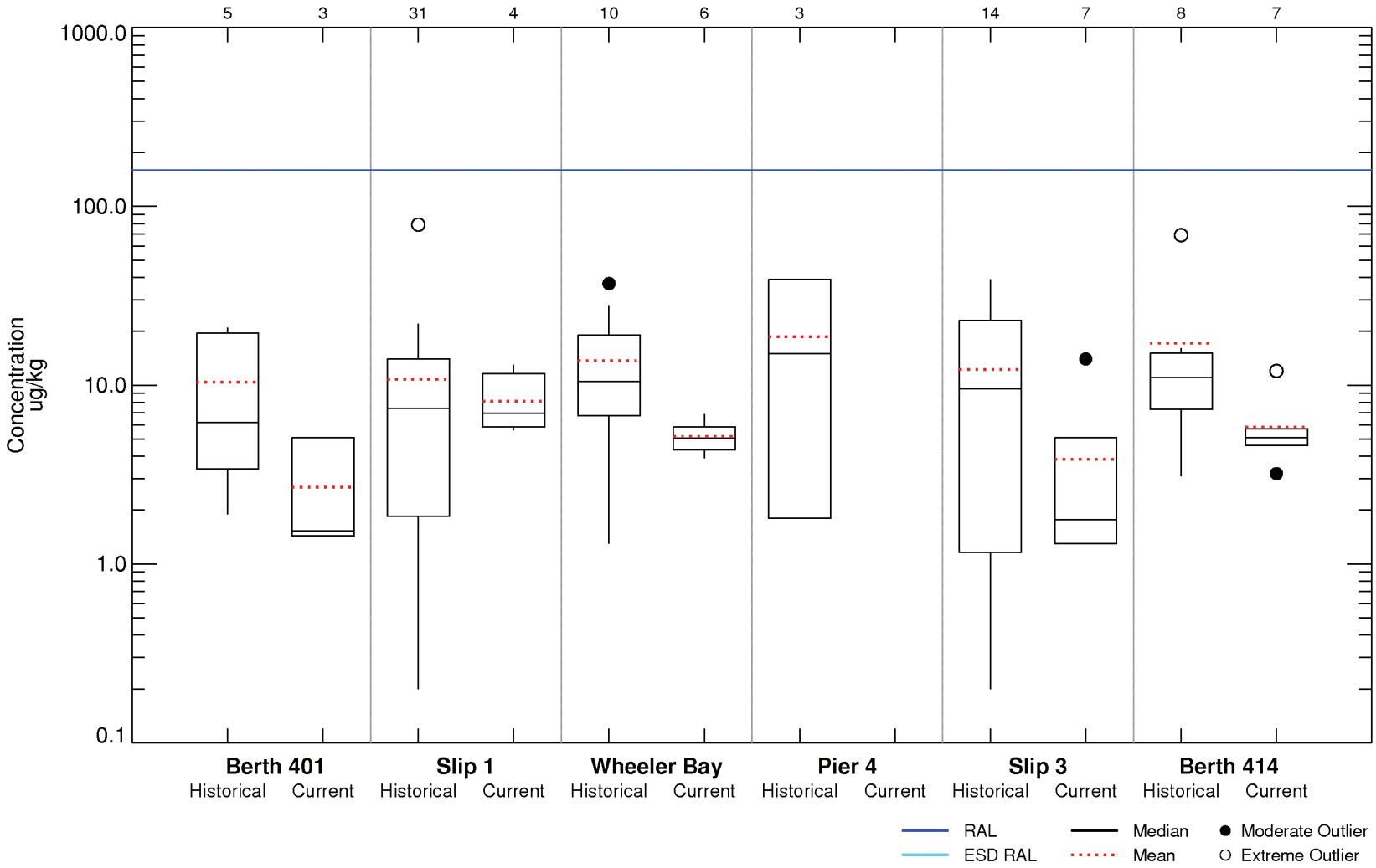
Figure F-6b
Historical Versus Current Data Comparison by Subarea: Total PCBs (Aroclors and Congeners U=1/2)



Notes:
- Sample counts displayed at top of each box plot.
- Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data are within the box boundaries. The whiskers represent the remaining data minus the outliers. The moderate outlier value is greater than the third quartile plus 1.5×IQR or less than the first quartile minus 1.5×IQR. The extreme outlier value is greater than the third quartile plus 3.0×IQR or less than the first quartile minus 3.0×IQR.

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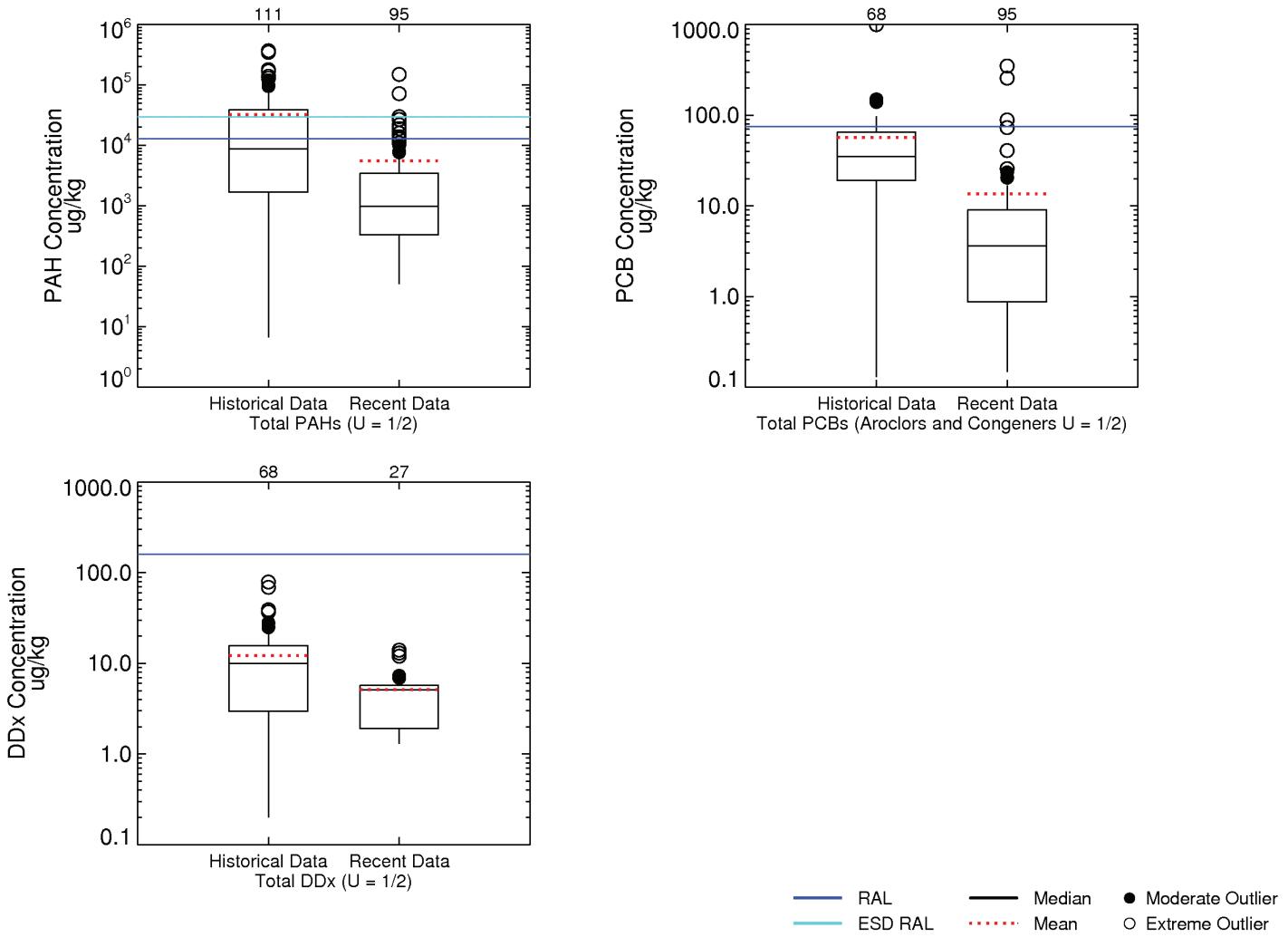
Figure F-6c
Historical Versus Current Data Comparison by Subarea: Total DDx (U=1/2)



Notes:
- Sample counts displayed at top of each box plot. Pier 4 underpier data are not included in site-wide plots.
- Tukey Box boundaries display the interquartile range (IQR) of the distribution ranging from the first quartile to the third. The central 50% of data are within the box boundaries. The whiskers represent the remaining data minus the outliers. The moderate outlier value is greater than the third quartile plus 1.5×IQR or less than the first quartile minus 1.5×IQR. The extreme outlier value is greater than the third quartile plus 3.0×IQR or less than the first quartile minus 3.0×IQR.

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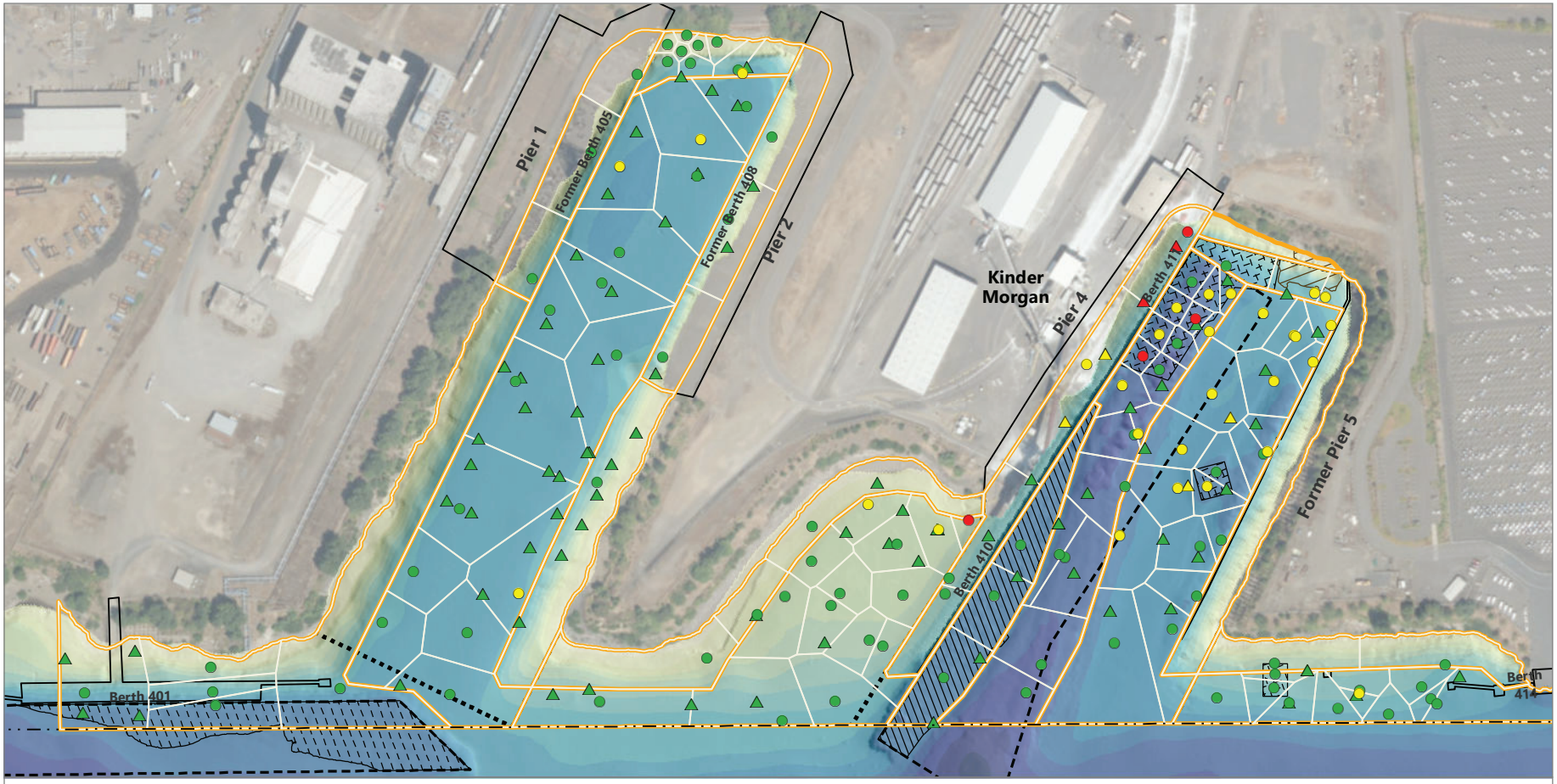
Figure F-7
Historical Versus Recent Sediment Chemical Concentration Time Trends



LEGEND:

- Navigation Channel
- Site Subarea Boundaries
- Berth 410 Maintenance Dredging (2017)
- Berth 401 Maintenance Dredging (2015)
- Terminal 4 Early Action Dredging (2008)
- Early Action Sediment Cap
- Thiessen Analysis Boundaries
- Thiessen Polygons
- Historical Locations For Thiessens
- T4 PDI/Pre-RD Group Locations

Total PAH (µg/kg)

- ≤ 30,000
- 30,100 - 170,000
- > 170,000

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 1991) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. SDU boundary extends approximately 1,000 feet upstream from the extent shown.

0 400

Feet

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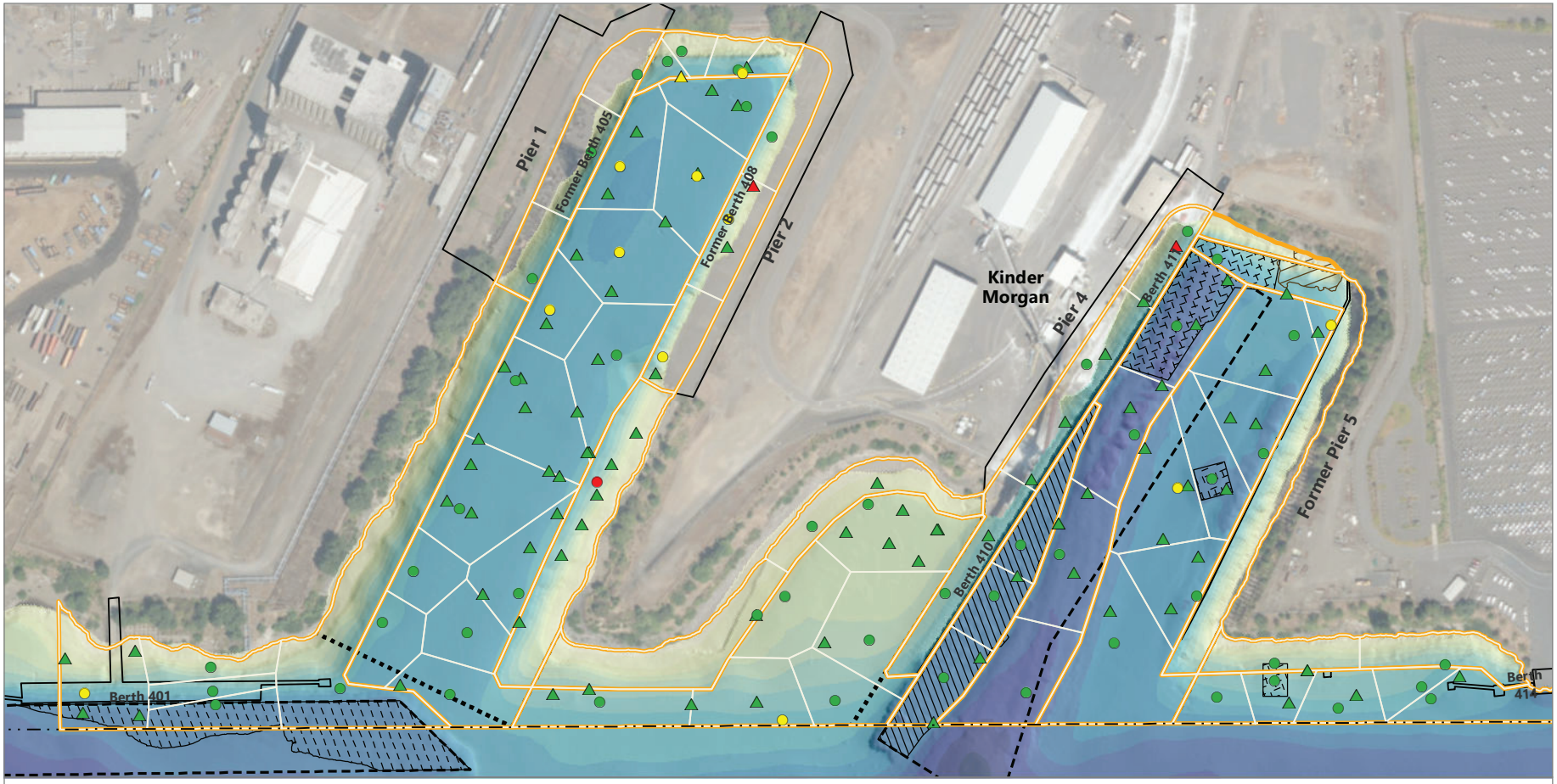
Figure F-8a
Historical and Recent Data Pairings for Total PAH
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy



LEGEND:

- Navigation Channel
- Site Subarea Boundaries
- Berth 410 Maintenance Dredging (2017)
- Berth 401 Maintenance Dredging (2015)
- Terminal 4 Early Action Dredging (2008)
- Early Action Sediment Cap
- Thiessen Analysis Boundaries
- Thiessen Polygons
- Historical Locations For Thiessens
- T4 PDI/Pre-RD Group Locations

Total PCB (µg/kg)

- ≤ 75.0
- 75.1 - 200
- > 200

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 1991) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. SDU boundary extends approximately 1,000 feet upstream from the extent shown.

0 400
Feet

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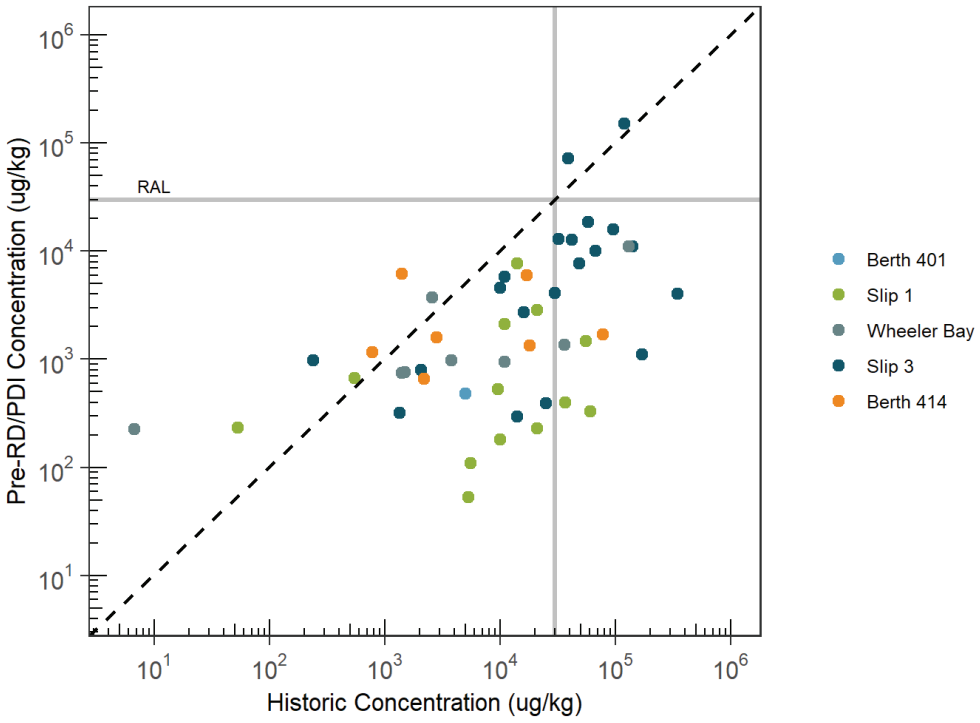
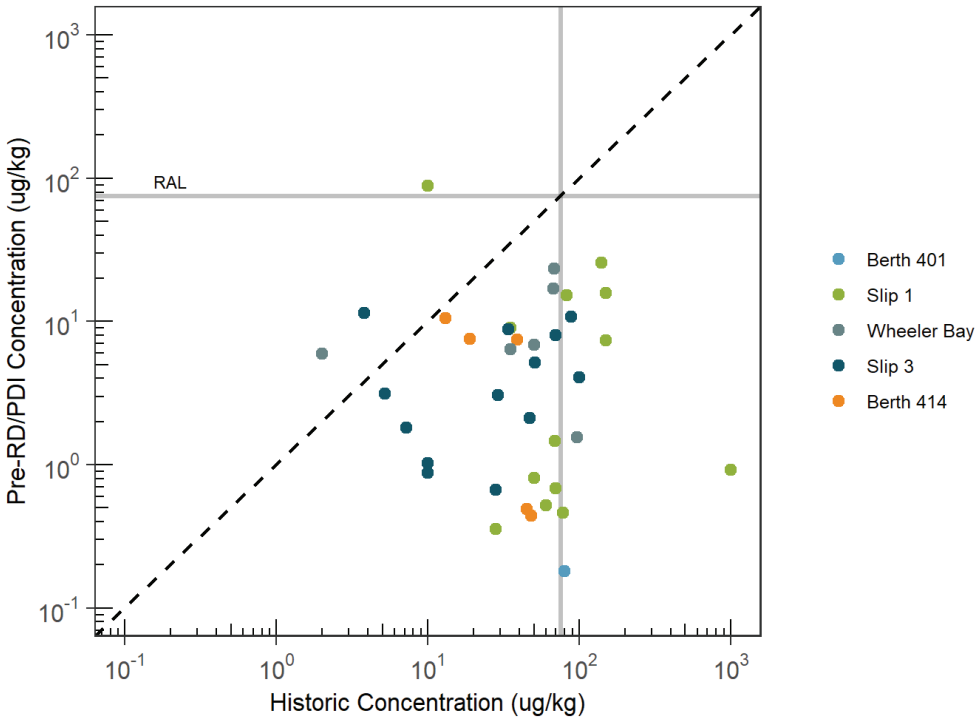
Figure F-8b
Historical and Recent Data Pairings for Total PCB
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy

A. Total PAHs



B. Total PCBs



Note:
RAL: Portland Harbor remedial action level

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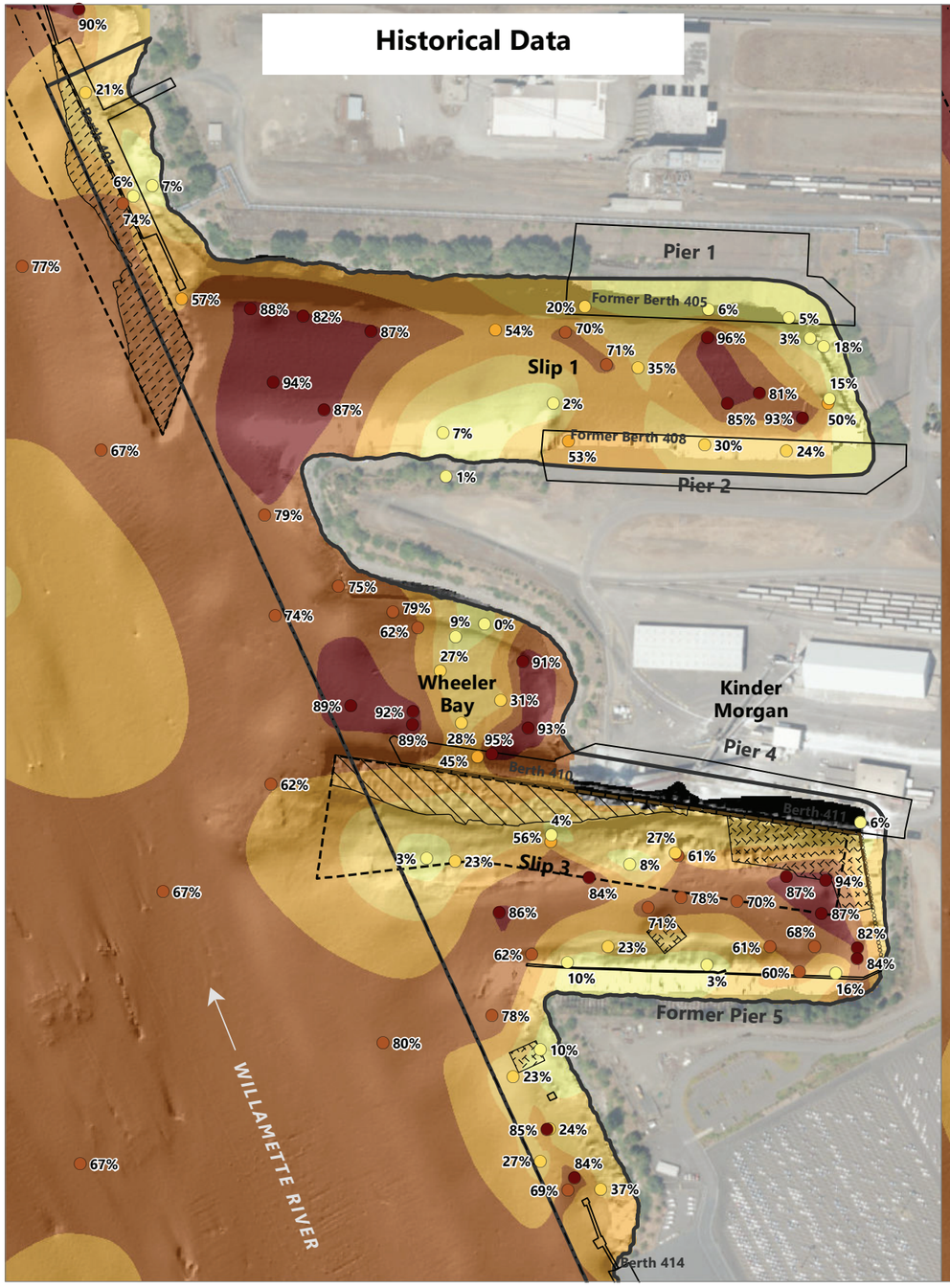
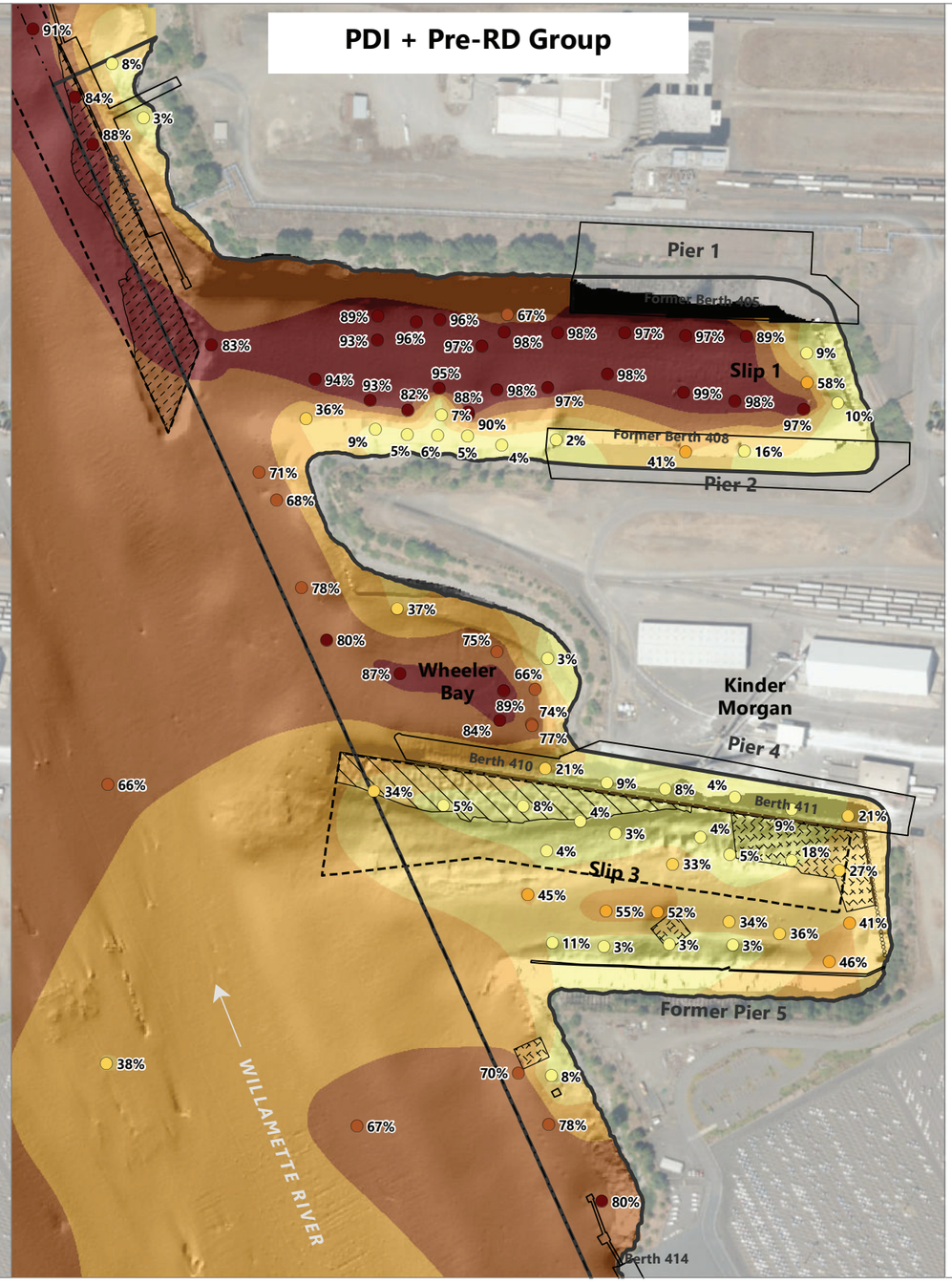
Figure F-9
Pair Comparison Plots of Historical Versus Recent Data
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy





LEGEND:

- Sediment Decision Unit RM 4.5E
- Navigation Channel
- Shoreline Structures
- Sheet Pile Wall
- Timber Pinch Pile
- Potential Maintenance Dredging
- Terminal 4 Early Action Dredging (2008)
- Berth 401 Dredging (2015)
- Berth 410 Dredging (2016)

Percent Fines

- 1% - 20%
- 21% - 40%
- 41% - 60%
- 61% - 80%
- 81% - 106%

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 1991) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. Bathymetric survey performed by David Evans and Associates in 2018.
5. Historical surface sediment locations are from the USEPA FS Database.
6. SDU boundary extends approximately 1,000 feet upstream from the extent shown.

0 400
Feet

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Figure F-10
Percent Fines Distributions in Historical and Recent Surface Sediments
Appendix F: Pre-Remedial Design Investigation Summary Report
Terminal 4 Remedy